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JOHN W. FINCH, DIRECTOR

INFORMATION CIRCULAR

MINING METHODS AND COSTS AT THE CRESSON MINE, CRIPPLE CREEK, COLO.

BY

A. H. BEEBE AND C. H. JOHNSON

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By A. H. Beebe [2] and C. H. Johnson [3]

INTRODUCTION AND ACKNOWLEDGMENT

This paper describing the operations of the Cresson mine of the Cresson Consolidated Gold Mining & Milling Co. at Cripple Creek, Colorado, is one of a series of papers on mining methods and costs being prepared by the United States Bureau of Mines.

The Cresson has recently been the most important mine in the Cripple Creek district. During 1932 and 1933 an average of 230 tons of new ore (excluding dump material) that averaged about $10 in gold was shipped daily; 150 to 175 men were employed. Stoping was by the shrinkage method exclusively. The ore was screened, washed, and hand-sorted at the surface and shipped to the Golden Cycle mill at Colorado Springs for treatment. A considerable proportion of the production was made by lessees working under the so-called "split-check" system.

The authors are indebted to the management of the Cresson Consolidated Gold Mining & Milling Co. for permission to publish this paper.

HISTORY

The Cresson mine was opened about 1903 in a previously unproductive part of the district. During the next 10 years it was gradually developed; it was usually a small producer but was generally regarded as having poor prospects.

In late 1914 stope development on the 1200 level disclosed a natural cave, containing high-grade ore on the floor and walls, and from which during the next 6 months a reported net total of about $1,200,000 in gold was mined. This gave the property immediate prominence. In July 1916 it was acquired by the present company. Under the new management production has been continuous

1 - The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6806."

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at rates ranging from 200 to 400 tons per day. As early as 1912 the approach of the Roosevelt tunnel had lowered the water level in the Cresson, and development progressed downward. Actual connection to the tunnel was made in 1918; large ore bodies were developed and mined on the tunnel (17th) level. In 1922 preparations were begun for deeper exploration that involved a virtually new surface plant, 465 feet of shaft sinking, and the installation of heavy pumping equipment. During development of the 19th and 20th levels flows of nearly 5,000 gallons per minute were pumped to the tunnel level. Large ore bodies were found, but of somewhat lower grade than expected; development work was more costly, and other mining costs were increased, so that after about 6 years of intensive prospecting and development, and the mining of large tonnages from the levels below the tunnel, these were abandoned in 1929. In 1930 the upper levels of the mine were opened to leasings, which have become steadily more important, yielding 40 percent of the total mine ore shipped in 1932.

The total production of the mine from 1903 through 1933 was as follows:[4]

Dry short tons	2,122,298
Gross value	$35,331,783.95
Freight and treatment	$10,826,914.15
Net value	$24,504,869.80
Average gross value per ton	$16.65
Average net value per ton	$11.54
Dividends	$12,454,472.50

The above dividends were paid on a total of 1,220,000 shares of a par value of $1.

GEOLOGY[5]

The Cresson mine is in the south-central part of the huge volcanic neck of phonolite in and about which are grouped the productive mines of the district.

Geology and Physical Characteristics of Ore and Country Rocks

The Cresson ore bodies lie mainly about the periphery of a pipe of basaltic breccia known as the Cresson breccia or "blow-out," which is intrusive into the main Cripple Creek volcanic neck. A number of large and small ore bodies, however, have been found within the blow-out, and others have been found at a considerable distance outside the contact; the latter usually were of the fissure vein type and generally associated with basalt dikes. The Cresson breccia intrusive is roughly oval near the surface, being about 500 feet wide and 700 feet long; at depth it flattens, and at the 1700

4 - Report of Cresson Consolidated Gold Mining & Milling Co. for year ending Dec. 31, 1933.

5 - Mainly from Laughlin, G. F., Ore at Deep Levels in the Cripple Creek District, Colorado: Trans. Am. Inst. Min. and Met. Eng., vol. 75, 1927, pp. 42-73.

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level it is about 200 to 300 feet wide and about 1,100 feet long. The contact is roughly distinct, but often very irregular.

The ore bodies of this mine are very different from the relatively narrow fissure veins typical of the district; they consist of irregular masses of mineralized breccia, only very crudely lens-shaped or tabular, usually standing vertical and lacking any well-defined pitch. The width of the minable ore usually ranged from a few to 50 or 75 feet, the length up to perhaps 300 feet, and the depth up to 200 or rarely 300 feet. The average width of the ore bodies being worked in early 1933 was about 25 feet.

The distribution of values within the ore body is erratic; small and large horses of waste are encountered, and the walls and trend of the ore are so irregular that no stope layout can be designed in advance of stoping. Stoping limits usually are determined by assay; less often the mineralization stops at a contact.

The chief ore mineral is the telluride, calaverite, which occurs as crystals lining vugs or cracks or impregnating the country rock or gangue minerals. The common associated gangue minerals are quartz, fluorspar, pyrite, dolomite, and celestite.

It is impossible to estimate the grade of the ore by eye, therefore sampling is relied upon to guide stoping. Experienced men, however, can distinguish ore from barren or very low-grade rock well enough to make hand-sorting feasible.

Both ore and country rock stand very well, so that little timbering for support is necessary; only the basalt dikes need timbering places because of a tendency to slab. In shrinkage stoping backs 50 feet or more wide stand safely, and old, empty stopes stand open indefinitely without caving. The ore is moderately hard to drill but breaks well on blasting. Much of the ore is characterized by a porous, "vuggy" texture; this, according to the present management, makes diamond drilling unreliable for estimating grade of ore, although the size and fair continuity of the stopes might lead to the impression that drill holes would yield significant results.

PROSPECTING, EXPLORATION, AND SAMPLING

Prospecting and exploration are done by drifting and raising; prospect headings frequently are run from stopes. Few "guides to ore" are recognized, although the general association of basalt dikes with the ore bodies is used as a guide in prospecting new country. As the ore cannot safely be projected far ahead of actual exposures, exploration workings follow the ore as closely as possible; hence drifts are exceedingly crooked.

A great amount of sampling is done to guide both exploration workings and stoping as well as to control the grade of material hoisted for ore and to serve as a check upon sorting operations. All faces, whether in ore or waste, are sampled after each round by taking at least two cuts across the

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face; moreover, two or more grab samples are taken from the muck pile. This is done as part of the daily routine of the foreman and shift bosses. Samples thus taken early in the morning are assayed during the day, and the results are available before the end of the shift.

Assaying is done by a chief assayer and four assistants, who run about 300 samples daily, of which 50 to 100 are from other properties than the Cresson.

Contour maps are made of all stopes, from which estimates of broken ore reserves are made, allowing for the waste that will be removed in the ore-house. The grade of these reserves is estimated from all grab samples taken in the course of stoping.

DEVELOPMENT

The mine is worked through a two-compartment vertical shaft 2,400 feet deep, situated about at the center of one side of the Cresson "blow-out." Levels are spaced at approximately 100-foot intervals from the collar at 10,030 feet above sea level to the tenth level at elevation of 9,035 feet. From there to the 20th level the interval ranges from 110 to 155 feet and averages 130 feet. The 1700 level is connected with the Roosevelt tunnel, which drains the active levels of this mine as well as most of those in the district. Several levels above this connect with shafts on neighboring properties. Below the 1700 the workings have been allowed to flood since last worked in 1929. Figure 1 shows the workings of the 1100 level and indicates clearly the complexity of the problem of finding and following the ore. Stopes are worked through manways spaced as convenient, or as permitted by existing drifts and crosscuts, and not at regular intervals; the average spacing of drawing chutes under the larger shrinkage stopes is about 25 feet. Connections are made to upper levels from the stopes when needed for ventilation or to facilitate the handling of supplies.

The main shaft is 4 by 8 feet in the clear, and is timbered with 8- by 8-inch sets at 5-foot centers. The skip compartment is 4 by 4 feet in the clear; the other compartment provides for the counterbalance, air and water lines, electric cables for lighting stations and signals, and a ladderway. The shaft has not been deepened since 1934.

Stations are cut usually 15 feet high and 15 feet wide at the shaft, tapering to a height of 7 or 8 feet at a distance of 10 or 15 feet from the shaft and to drift width at a point 25 to 50 feet away. Stations usually are cut out on both sides of the shaft.

All drifts and crosscuts are about 5 by 7 feet in size and nearly all untimbered. Drilling was done with Denver-Gardner No. 7 drifting machines mounted on 3-1/2-inch vertical columns, using 1-1/8-inch hollow round steel. Standard crossbits with double taper, gage changes of 1/8 inch, and length changes of 20 inches, were used. A round consisted of 10 to 22 holes, depending on the nature of the ground. A modified hammer-type round with a "burned"

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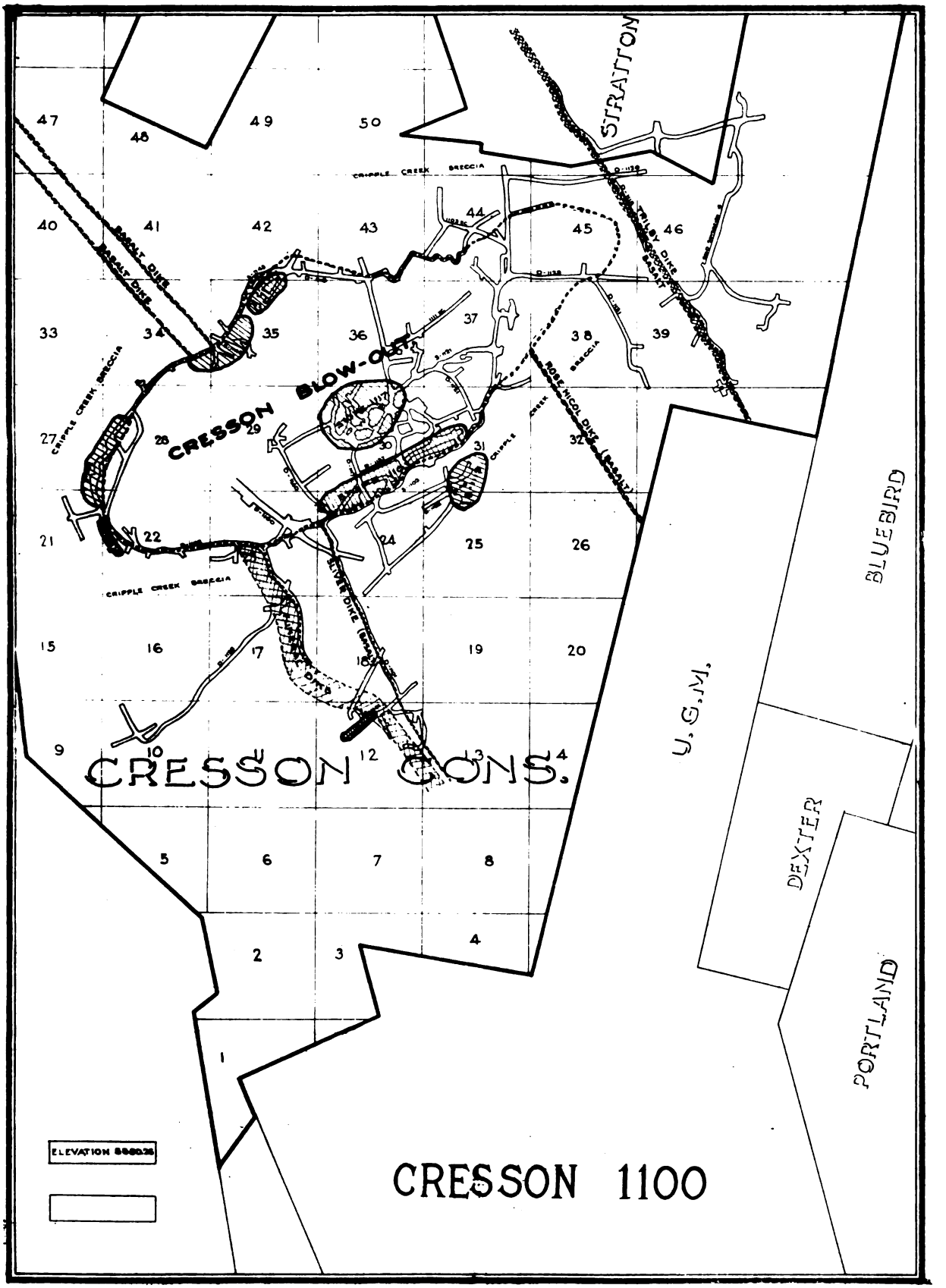

Figure 1.—Plan of a typical level.

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cut was generally used and broke an average of 3 feet. Blasting was done with 40-percent-strength, semigelatin powder, Sylvanite fuse, and No. 6 caps. Stemming was not used, principally because it made the shooting of missed holes difficult. A safety rule prohibited drilling in the vicinity of a missed hole until the hole had been blasted.

All mucking was done by hand, loading into 16-cubic-foot (1,600-pound), box-type, end-dump cars.

Raises were driven as needed for shrinkage-stope draw points and for ventilation. Considerable prospect work also was done by raising. The raises were about 6 by 8 feet in the clear; drilling was done by one miner, using a self-rotating Ingersoll-Rand No. R-51 wet stoper.

In 1932 the company did 5,152 feet of drifting and 1,130 feet of raising; lessees did 1,893 feet of drifting, 774 feet of raising, and 10 feet of winze. The total development footage was 8,959 feet. On the basis of 61,914 tons shipped (excluding dump ore) this amounted to about 1 foot of development for every 7 tons of ore. It is noteworthy, however, that the company performed 1 foot of development for every 5.6 tons of company ore shipped, whereas the lessees did only 1 foot for every 10.1 tons of lessee ore.

STOPING

The shrinkage method of stoping was used because of the excellent walls and back, the fair width of the stopes, the desirability of having sufficient reserves of broken ore to make possible some measure of control over mine ore grade, and the impossibility of any systematic open-stope method requiring advance development, such as sublevel stoping.

Figure 2 shows an elevation and transverse sections of a typical medium-size stope.

Drilling in stopes was done chiefly with self-rotating Ingersoll-Rand R-51 stopers, using 1-inch, hollow, hexagon steel. Holes were drilled 4 to 8 feet deep and 18 inches to 4 feet apart, when mining normally upward. However, due to the irregularity of stope boundaries, drifter rounds and underhand rounds with jackhammers were occasionally necessary. Blasting was done with DuPont Gelex No. 2 dynamite, Sylvanite fuse, and No. 6 caps.

Stope crews, whether on company account or in leases, consisted of 2 or 3 miners and 1 or 2 muckers if needed; the latter assisted the machinemen in setting up, barred down, handled steel, broke boulders, and shoveled ore from flat benches whence it would not run by gravity.

Manways into the stopes were single-compartment, cribbed solidly with half-dapped, round, 4- to 6-inch cribbing or were carried up as stulled-and-laced manways on the stope ends. When necessary, such manways could be maintained through broken ore for the life of stopes 75 to 125 feet high; however,

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above 75 feet maintenance became difficult, and usually access was more convenient from the level above. Chutes were of timber construction, 3 feet wide, ruggedly built, with heavy plank control boards. Usually rock pillars were left over the drift between chutes; in a few instances in narrow ore bodies or where the ore body was believed to be of small vertical extent, the broken ore was carried on stulls over the drift. An effort was made to reduce all boulders in stopes to 12 inches or smaller before they were buried or drawn into the muck. Probably only 1 or 2 percent of the rock broken required secondary blasting, and perhaps 5 percent was broken by hammering.

TRAMMING AND HOISTING

All tramming from stopes was done by hand. Most company ore was trammed by men working on contract, who were paid according to the number of skiploads trammed. The average tramming distance from stopes to shaft was about 600 feet. At the shaft the cars were dumped into pockets of 20 to 75 tons capacity. Each level had 1, and 1 level, 2 pockets. An unusual feature was the grizzly through which the ore was dumped. This was made up of one or more heavy, rectangular, cast-steel units about 4 feet wide, 5 feet long, and 8 inches deep, with 10- by 12-inch openings separated by webs 4 inches thick. They were of manganese steel and had a life of several years, far greater than that of the chilled-steel castings formerly used, which wore out rapidly as soon as the hard surface was penetrated.

The ore was hoisted in a 4-ton skip, above which was a platform for hoisting men. The necessity of hoisting from many levels increased the cost. In 1932, 7 levels from the 8th to the 17th each contributed 10 to 20 percent of the total company ore hoisted, and the 3 other levels smaller amounts. In addition, lessee's ore was hoisted from several levels above the 8th.

The hoist was a Webster, Camp & Lane first-motion, double-drum, steam hoist, using steam at 140 pounds pressure in twin single-expansion cylinders. Steam was furnished by one of two 250-hp. Aultman-Taylor boilers, used alternately for 3-month periods. One boiler was fired by an automatic stoker, the other by hand. The coal used was lignite slack from the Colorado Springs field. The present hoisting plant was installed in 1923 and designed to serve the needs of the mine to a possible depth of 3,000 feet. The boilers also provided steam to heat the orehouse and surface plant.

From 300 to 350 tons of ore (including lessees' production) and 80 to 100 tons of waste were hoisted daily. All waste was hoisted to the surface.

The skips were dumped into a two-compartment, 35-ton bin at the collar. Ore was trammed in 4½-ton cars by an electric locomotive to the orehouse and waste by the same equipment to the dump.

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VENTILATION AND DRAINAGE

The mine was ventilated by natural air currents coming through the drainage tunnel and connections to adjoining mines. Small motor-driven fans and flexible ventilating pipe were used to remove smoke and gas from blasting in dead ends. A ventilation door was installed in the drift leading to a gassy section of the mine; work was carried on there under a slight pressure created by a motor-driven fan, which was enough to hold the gas back in the rock.

The mine workings above the tunnel level were virtually dry. The workings on the tunnel level made about 25 gallons per minute. There was very little flow into the tunnel from the flooded levels below. Altogether the Cresson workings contributed from 50 to 100 gallons per minute directly to the total flow in the Roosevelt tunnel. However, a portion of the Cresson flow is probably represented by water entering the drainage tunnel much nearer the portal.

SORTING

Between 35 and 40 percent of all ore hoisted was discarded by sorting in the orehouse at the surface; no sorting was done underground.

The company ore was sorted in one section of the orehouse and lessees' ore in the other. Provision was made for handling the production from 10 sets of lessees at a time. Lessees' ore was dumped over grizzlies set 4 inches apart, under which was a double woven-wire screen with 1½- and 7-inch square openings. The screen oversize went to a 30-ton intermediate pocket and the undersize directly to a tramway loading pocket. The screen oversize was drawn out over steel-topped sorting benches about 2 1/2 feet wide and 4 feet long, at which two sorters could work. The waste was thrown into small mine cars, which were hand-trammed to outside waste bins, whence the waste was trammed in 2-ton electric side-dump waste cars to the waste dump or carried by conveyor to a higher level where it was similarly handled.

Company ore was dumped into a hopper, then passed through two revolving, wet trommels, 4 feet in diameter and 16 feet long, with maximum openings 1 1/2 inches in diameter. The undersize went to a 75-ton tramway loading pocket. The oversize went onto a rubber picking belt 24 inches wide and about 30 feet long, at which 5 or 6 sorters could work; the normal crew on a belt was 4. The ore was picked out and dropped into chutes or openings beside the belt; the waste dropped from the end of the belt into a small pocket, whence it was handled similarly to the lessees' waste. The two trommels and two picking belts were arranged in parallel, but with the scale of operations prevailing in 1932-33 they were used alternately.

The ore was transported to the railroad loading point, a distance of 2,600 feet and 300 feet below the orehouse, by a wire-rope, aerial tramway.

The boss sorter, by daily sampling, kept a close check on all ore going through the orehouse.

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AIR COMPRESSION

Compressed air was supplied by three Ingersoll-Rand motor-driven compressors. The largest was a class P R E 3, 27- by 15 3/4- by 18-inch machine, direct-connected to a 305-hp. motor. The second was an Imperial, Type 10, 25- by 14- by 20-inch compressor, belt driven by a 250-hp. motor. These two divided most of the load about equally. The third and smallest compressor, an Imperial, Type 10, 18- by 10- by 14-inch, driven by a 100-hp. motor, was used mainly for peak loads.

STEEL SHARPENING

Three men in the steel shops sharpened about 600 pieces of steel daily, in addition to making up new steel. Two Ingersoll Rand No. 5 sharpeners and three oil furnaces were used.

ORGANIZATION

The office of the president and general manager of the company was in Colorado Springs. The superintendent was in charge at the mine, with a mine foreman, master mechanic, chief assayer, and bookkeeper as his immediate subordinates. The mine foreman was assisted underground by two shift bosses and on the surface by an orehouse boss. Surface work other than in the orehouse, assay office, and mine office, was in charge of the master mechanic. Five men in purely supervisory positions and a general manager who divided his time between several operations thus directed the work of 110 company men and 65 lessees.

Engineering work was done by a local custom-engineering office and on the average required the attention of a two-man survey party about 6 to 8 days monthly.

Leasing System

In 1931 and 1932, roughly 40 percent of the mine ore shipped was produced by lessees under the usual Cripple Creek "split-check" system. This system was devised at the Portland mine at Victor, Colo., in 1913.[6] As used at the various Cripple Creek mines it differs in details. The following description applies to the Cresson mine.

Leases are given for 1 year, but work may be stopped at the discretion of the management. Leasing is carried on usually where ore has been left in pillars or along old stope walls but occasionally in other areas where the lessee believes undeveloped ore exists. Lease blocks are of different sizes, but generally 200-foot square and 1 level high. Lessees are required to put in at least 50 man-shifts a month. They are subject to all company rules regarding safety and sanitation. Pillars may be removed only with the management's

6 - Smale, F. L., Split-Check Leasing System Proven Very Effective in Cripple Creek: Min. Sci., May 1915, pp. 41-43; see also abstract in U. S. Geol. Survey Mineral Resources of the United States, 1914, pt. I, pp. 312-313.

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permission. The company reserves complete authority over the work, but such authority is exercised only in case of incompetence or dangerous or wasteful practices.

The company supplies compressed air, equipment (excluding only drills), explosives, and other supplies, and hoisting service and transports the ore from the orehouse to the railroad and loads it into the cars. A charge of 10 cents per ton is made for transporting the ore on the aerial tram and loading it into cars. The lessee provides only the labor, including miners, trammers, and ore sorters (in practice he usually is permitted to use such old machines as the company has available, free of charge) and pays his own compensation insurance. The company and the lessee divide equally the net returns (gross value less freight and treatment charges), less 1 percent of the gross value as the lessee's share of taxes, and less the handling and loading charge noted above.

Under this system men with little capital are enabled to undertake leasing, and as they can lose only their labor and are not faced with cash expenditure for each foot or ton of ground broken a relatively large amount of prospecting is done, and all favorable areas are searched thoroughly before being abandoned. This often leads to the discovery of ore beyond or below the lease boundaries that justifies company operation. The management keeps closely in touch with lease work and avoids wasteful use of supplies by issuing only such as appear necessary.

In 1933 about 25 leases were in effect at once, employing 60 to 75 men.

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COSTS

The following costs (table 1) represent the operating costs based on dry tons of both company and lessees' ore shipped to the mill.

	1931	1932	1933			
			January	February	March	April
Company ore, net tons.	34,674	35,373	.....	.....	.....	.....
Lessees' ore, net tons	20,073	26,541	.....	.....	.....	.....
Total, net tons	54,747	61,914	5,274	4,688	5,628	4,861
Costs, per ton:						
Shift bosses	$0.20	$0.16	$0.14	$0.15	$0.14	$0.16
Breaking	1.78	1.57	1.35	1.44	1.37	1.53
Tramming	.63	.52	.47	.44	.42	.53
Timbering	.25	.26	.27	.22	.21	.20
Hoisting	.56	.47	.56	.48	.45	.47
Blacksmith	.18	.15	.18	.22	.16	.20
Assay office	.10	.08	.10	.03	.13	.04
General office	.02	.03	.03	.03	.03	.03
Machinist	.24	.22	.28	.22	.15	.17
Sorting and loading.	.50	.40	.40	.49	.50	.46
General operation...	.29	.18	.22	.23	.25	.22
Taxes	.13	.09	.09	.14	.09	.11
Compensation	.13	.11	.10	.09	.09	.09
Orehouse 1/	.13	.....	.....	.....	.....	.....
Total	$5.14	$4.24	$4.19	$4.18	$3.99	$4.21

1/ Remodeling orehouse to accommodate lessees' ore.

The above tonnages and costs exclude operations on an old dump from which considerable amounts of ore (25,000 tons in 1931 and 15,000 tons in 1932) were mined and loaded into railway cars by a combination of drag scraper and cable cars at a point near the lower end of the Cresson mine aerial tramway. The cost of this work was $0.61 per ton in 1931 and $0.76 in 1932 and averaged only $0.32 in the first quarter of 1933. These costs included power, labor, and the few supplies used for the scraping.

The costs in table 1, while based on the total of company and lessees' ore, take no account of lessees' labor, lessees' compensation payments, or other expenditures. As the labor by lessees in breaking, tramming and ore sorting comprised 35 to 40 percent of the total labor on surface and underground, the costs are misleading to that extent. As lessees received their pay in the form of half the net mill returns, this amount may be fairly added to the costs in table 1. In 1931 payments to lessees, divided by the total of lessee and company ore (excluding dump ore), amounted to $1.42 per ton, and in 1932 to $1.59. Added to the figures in table 1, these would increase the total mining costs for 1931 and 1932 to $6.56 and $5.83, respectively.

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The total force at the mine (early 1933) was approximately as follows:

Surface:	
Superintendent	1
Bookkeeper	1
Assayer	1
Assayer's assistants	4
Master mechanic	1
Machinist	1
Drill repair man	1
Electrician	1
Blacksmiths and tool sharpeners	3
Blacksmiths' helpers	3
Carpenter	1
Carpenter's helper	1
Hoist engineers 1/	2
Extra engineer	1
Repair crew	2
Watchman 2/	1
Aerial tramway operators	5
Orehouse boss	1
Orehouse men (electric tram car men, grizzly men, and company ore sorters)	17
Company top men 1/	2
Coal tramway operator	1
Dump miners	3
Total surface	54
Company, underground:	
Mine foreman	1
Shift bosses	2
Company miners	13
Company trammers 1/	14
Timbermen	2
Trackmen	2
Contract miners	3
Contract muckers and trammers 3/	14
Powderman	1
Cagers 4/	4
Total company underground	56

1 - One on night shift.

2 - On night shift.

3 - Three on night shift.

4 - Two on night shift.

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Total company men and contractors, surface and underground	110
Lessee miners	35
Lessee muckers and trammers	30
Lessee ore sorters	10
Total lessee men	65
Total all men	175
Total underground	111
Total surface	64

The wage scale effective September 1, 1933 is given below. Previous to that date wages were 10 percent lower.

Machinemen	$4.40
Muckers and trammers	3.85
Timbermen	4.40
Timbermen (shaft)	5.75
Carpenter	4.75
Trackmen	4.75
Trackmen helpers	4.25
Skiptenders	5.50
Skiptenders' helpers	5.00
Topmen and motormen	4.15
Machinist	5.25
Electrician	5.00
Engineers	5.25
Watchmen	4.15
Firemen	4.40
Blacksmith	5.00
Blacksmith helpers	3.85
Sharpeners	5.25
Sharpeners' helpers	$4.15 - 5.00
Ore sorters	3.60
Assayer helpers	4.15
Dump labor	3.85
Drag hoistman	4.40

The average daily tonnage of ore shipped in the first four months of 1933 was about 205 tons, or 1.2 tons per man-shift for the total organization, or 1.9 tons per underground man-shift (excluding labor and tonnage of dump mining). The ore hoisted in the same period was about 2.9 tons per man-shift underground.

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Daily wages of company men and contractors averaged $4.71 in 1931 and $4.18 in 1932. Using the latter figure and assuming that the average earning of lessees was the same, the labor cost per ton of new ore shipped in the first 4 months of 1933 was about $3.50.

The following tabulation shows a consistent relation, over considerable periods, between machine shifts and tonnages of ore and waste produced.

	Tons per machine shift		
	1931	1932	1933[1/]
Tons shipped	5.9	6.5	6.7
Tons of ore hoisted	10.1	10.2	10.4
Tons of ore and waste hoisted ...	12.9	13.4	13.7

1/ January to April, inclusive.

The cost item of "shift bosses" shown in table 1 includes the mine foreman but not the superintendent whose salary is included in "General operation."

The amount of explosives for the year 1932 was 3.7 pounds per ton of ore shipped, 2.3 pounds per ton of ore hoisted, and 1.9 pounds per ton of ore and waste hoisted, that is, all material broken, assuming equal reserves of broken ore in stopes at the beginning and end of the year. The cost of dynamite was $0.51 per ton of ore shipped, $0.32 per ton of ore hoisted, and $0.27 per ton of ore and waste hoisted. The explosives used were about three fourths Gelex No. 2, a Du Pont bulk powder of 45 percent strength, averaging 120 sticks per 50-pound case, and one fourth Du Pont Special Gelatin of 40 percent strength, an ammonia-gelatin dynamite. The costs noted included freight to the point of delivery at the lower end of the mine aerial tramway, but no further handling charge. Fuse, which was used at the rate of about 3,500 feet daily, and caps, at the rate of about 500 per day, added an estimated amount of $0.14 per ton shipped, to the cost of explosives.

The cost of timber for chutes, stope manways, and minor miscellaneous uses, was about $400 monthly or, roughly, $0.08 per ton shipped, not including any cutting, framing, or handling charge. The sawed timber cost about $27.50 per 1,000 board feet, but as most of the timber used was purchased in round sticks the average cost per 1,000 board feet was probably less than $25; the timber consumption per ton shipped was not more than 3 or 4 board feet.

Electric power for air compression averaged about 10 kw.-hr. per ton of material hoisted, that is, broken, and about 20 kw.-hr. per ton of ore shipped, as shown by the following tabulation.

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Period	Kilowatt-hours per ton of:		
	Ore and waste hoisted	Ore hoisted	Ore shipped
1931	9.5	12.1	20.7
1932	10.9	13.2	20.8
January to April 1933	9.5	12.5	19.3

In addition, roughly 14,000 kw.-hr. per month was charged to surface lighting and various motor-driven machines, making an additional 3 kw.-hr. per ton of ore shipped.

The following is a list of the motors installed at the mine:

	Hp.
Class P R E 2 compressor	305
Large Imperial compressor	250
Small Imperial compressor	100
Generator	30
Machine Shop	15
Carpenter shop	15
Ore house washer	35
Drag hoist motor	52
Drag hoist motor	30
Aerial tramway	10
Ventilating fan on 1200 level	10
Seven small motors on grinding wheels, tramcars, etc.	30
Total installed horsepower	882

The electric power was purchased from the Colorado Southern Co., which had a hydroelectric plant 6 miles east of Victor, Colo., and a steam plant at Canyon City about 20 miles to the south. The rate depended only upon the total amount used and the horsepower installed; in effect it was close to $0.0165 per kw.-hr. Thus the power cost of air compression was about $0.33 per ton of ore shipped and the total electric power cost, excluding work on the old dump, about $0.38. About 30 drills were in daily use on one shift only; on this basis the cost of electric power for air compression was about $2.25 per machine shift. However, it is estimated that drill sharpening machines and other compressed air services are equivalent to about 10 machines; the power cost per machine shift as calculated to include this was about $1.65.

Coal for the boilers cost about $3.75 per ton, delivered to a point near the mine; water cost about $0.45 per 1,000 gallons. The following tabulation shows the consumption and cost of coal and water for 1931 and 1932:

	1931	1932
Coal, pounds per ton of ore shipped	132	138
Coal, pounds per ton of ore and waste hoisted	84	72
Water, gallons per ton of ore shipped	129	135
Water, gallons per ton of ore and waste hoisted ..	59	66
Cost of coal per ton of ore shipped	$0.34	$0.36
Cost of water per ton of ore shipped	.06	.06

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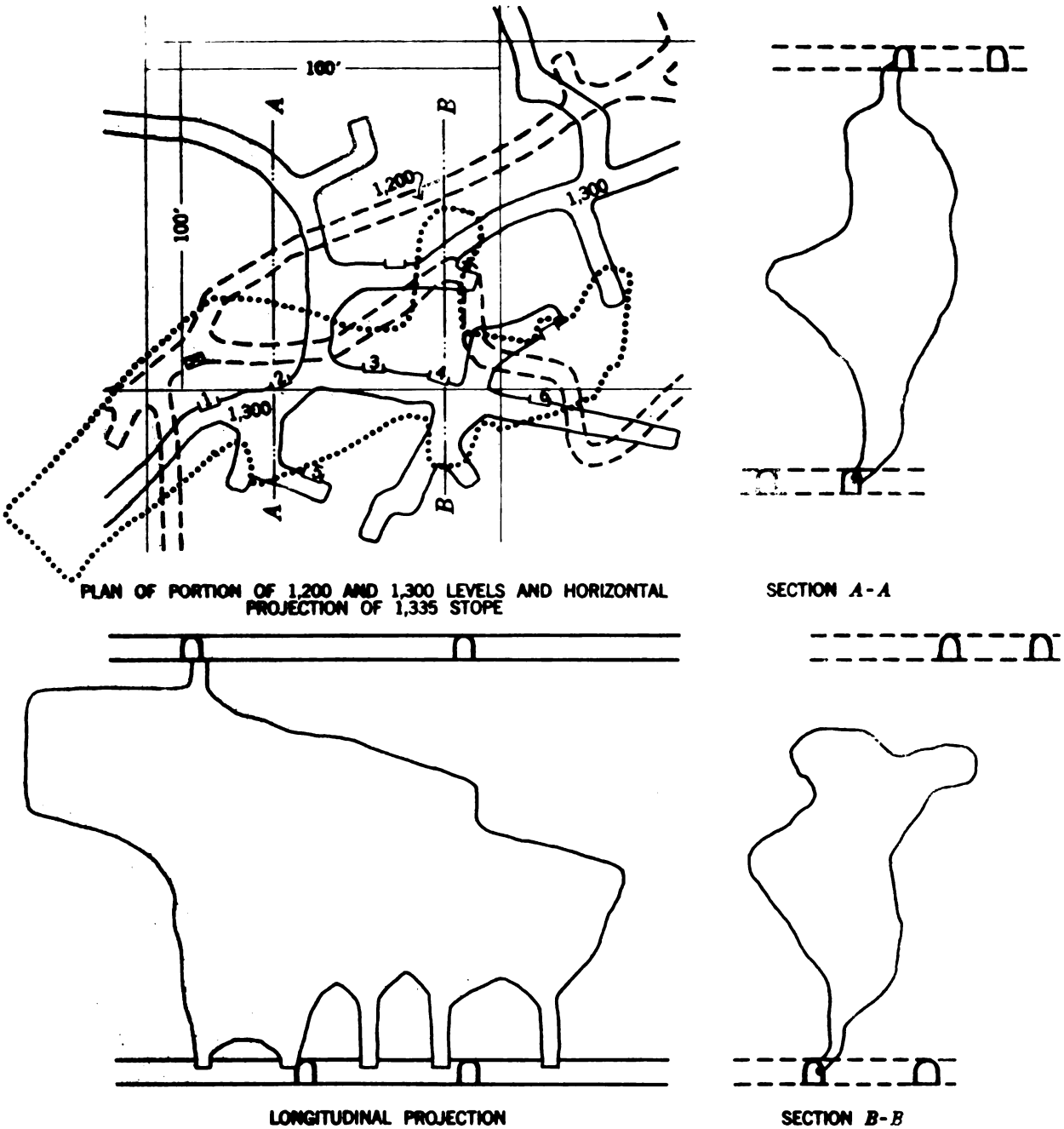

Figure 2.—Typical stope, Cresson mine.

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